The Greeks

2

If thou art able, O stranger, to find out all these things and gather them together in your mind, giving all the relations, thou shalt depart crowned with glory and knowing that thou hast been adjudged perfect in this species of wisdom.

Archimedes (c. 287–212 BCE)

The Dawn of Mechanics

As we have seen in Chap. 1, the Greeks were not the first to achieve scientific discoveries on Earth. Still, they are the first culture to assemble a significant body of scientific developments that has stood the test of time. Indeed, their impact on the world cannot be overestimated. At least a part of their achievements may be attributed to a societal taste for the written word. Indeed, the Greeks appear to be the very first culture on Earth to employ the written word ubiquitously, and although their language is certainly not the oldest on Earth, it is the first to employ vowels, thus making it more versatile than its predecessors. This thirst for the written word takes its roots in the works such as the Iliad and the Odyssey, by Homer, and written sometime in the eighth century BCE in an early version of Greek. Shortly thereafter numerous schools of belief began to develop, such as the Ionian School, the Atomistic School, the Stoic School, the Socratic School, the Aristotelian School, and the Pythagorean School. As such, the Greeks may be said to have developed the first systematic approach to education on Earth.

By the fifth century BCE, many works were written for public consumption. Perhaps the most important writer in Greek history was Herodotus (484–425 BCE), who wrote *The Histories*, for which he is considered to be the father of history (Fig. 2.1) [15]. While his oeuvre bears no direct relation to mechanics, *The Histories* influenced the subsequent development of the use of Greek, thus allowing scientists a means of recording their achievements and inventions both for posterity and the education of their progeny. Within a short period of time several other authors appeared, such as Thucydides, Xenophon, and Polybius. And while many of these were subsequently lost in time, quite a few survived, and as we will see below, a few are still being rediscovered today. Thus, it is apparent that the Greeks were the first culture on Earth to practice science systematically, and to utilize it for educational purposes.

D. H. Allen, *How Mechanics Shaped the Modern World*,
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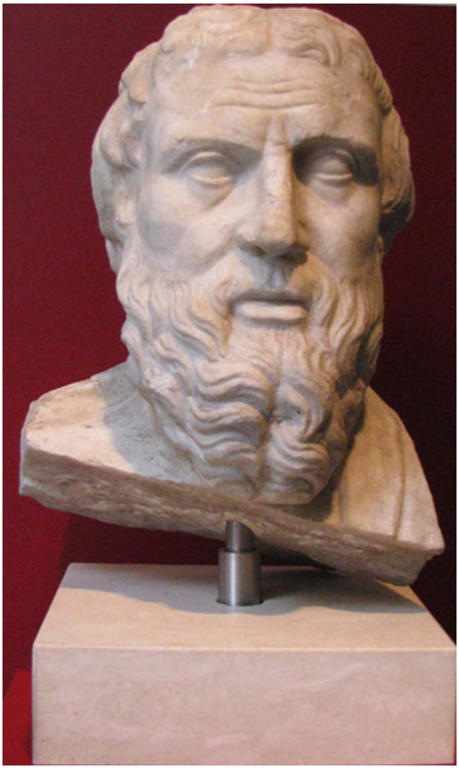

Fig. 2.1 Bust of Herodotus, National Museum of Rome

I suppose that the high point for the Greeks was the fifth century BCE, when Pericles (c. 495–429 BCE) and his colleagues built the Parthenon on the Acropolis in Athens (Fig. 2.2). The Parthenon was begun in 447 BCE and completed in 436. It was during that period that the Greeks established the first successful democracy on Earth (Fig. 2.3).

Interestingly, the Parthenon was partially destroyed when the Venetians bombed it on September 26, 1687, accidentally setting off an ammunition dump within. Today, the Greek government is engaged in a long-term effort to restore the structure to its original look. During the process, they have discovered that essentially every single piece of stone within the great structure was cut in place to fit a specific location, thus making it what some have described as the largest jigsaw puzzle on Earth. Indeed, the reconstruction of the Parthenon is an interesting challenge in mechanics.

More importantly, the Greeks became the first society on Earth to develop an advanced body of science. Apparently, their democratic form of government encouraged an explosion of scientific inquiry that produced discoveries that in many cases are still valid today. Numerous Greek scientists made advances in the field of mechanics during this period of history. The most remarkable of these are recounted briefly below in chronological order.

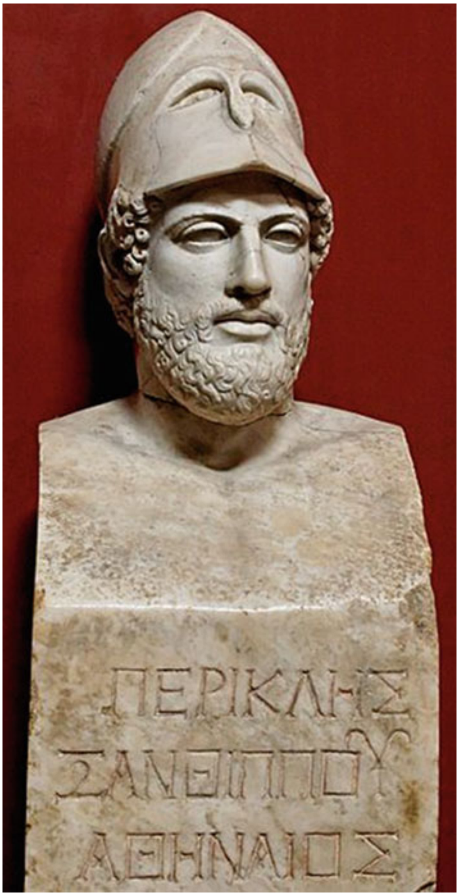

Fig. 2.2 Bust of Pericles, Vatican Museum

Fig. 2.3 Photograph of the Parthenon. *Note* the renovations underway

Thales of Miletus (c. 624–546 BCE)

Thales may be the first scientist known to us by name. Not much of Thales' works survive today. Thus, our primary means of determining his importance is via the numerous references to him by later philosophers and scientists. It seems that he was one of the first, if not the very first, to propose a scientific method based in logic rather than mythology. As such, his role in the evolution of science is self-evident.

As described in Chap. 1, there is a story that Thales visited Egypt once in his lifetime, and that the pharaoh asked him to measure the height of the ancient pyramid of Cheops. Thales did so by placing a gnomon in the ground and comparing the length of the shadow it cast to the length of the shadow cast by the great pyramid. This story demonstrates the ingenuity of Thales. Thales also is thought to have believed that the Earth is spherical, and he is known to have predicted a solar eclipse. There is little additional direct evidence of his accomplishments, but the universal reference to him by all those who followed is ample reason for his inclusion herein (Fig. 2.4).

Pythagoras of Samos (c. 570–495 BCE)

It is believed that Pythagoras, a student of Anaximander (c. 610–546 BCE), visited Thales early in his life, and that Thales affected him profoundly (Fig. 2.5). We know little about Pythagoras himself, but we do know that the Pythagorean School was all-important in the development of mathematics. For example, the theorem

Fig. 2.4 Depiction of Thales of Miletus

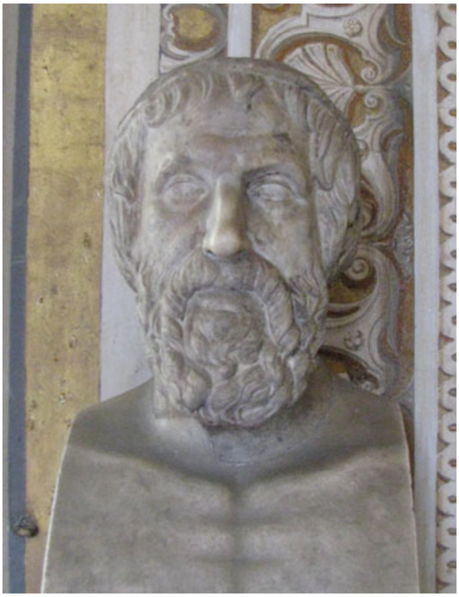

Fig. 2.5 Bust of Pythagoras in the Vatican Museum

that bears his name, called the *Pythagorean Theorem*, is one of the most important concepts in all of mechanics, providing a mathematical means of calculating the distance between any two points in space. Without this theorem, mechanics would not be a science.

Although there are no surviving documents proving that Pythagoras is responsible for the theorem that bears his name, the fact that this theorem does indeed bear his name suggests emphatically that the theorem was at least developed by someone within the Pythagorean School, if not Pythagoras himself.

Pythagoras is also known to have studied the nature of vibrating strings. This may have been related to the fact that he was an accomplished musician with the lyre. At any rate, he is known to have discovered that strings produce harmonious sound when the ratios of the lengths of the strings are whole numbers (more on this subject in Chap. 8).

Democritus (c. 460–370 BCE)

Democritus is considered by many to be the father of modern science. He formulated a complex theory of the universe that postulated the existence of atoms, the first reference in history to atoms. From the standpoint of mechanics, he may be considered to be the first person in Western culture to espouse a mechanistic view of the world, based on postulates that are rooted in experimental observation.

Democritus is sometimes called ‘‘the laughing philosopher'' due to his apparent penchant for scoffing at propositions with little or no logical basis (Fig. 2.6).

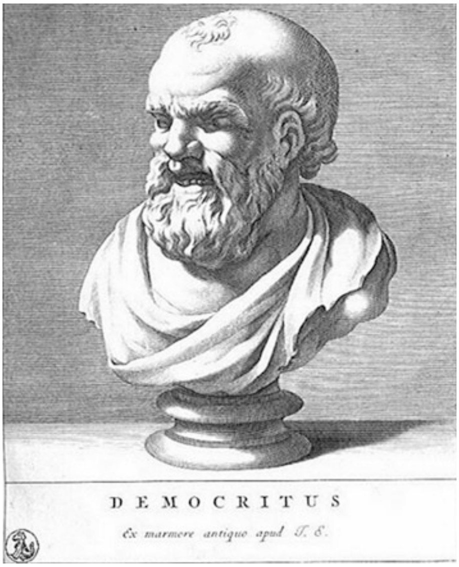

Fig. 2.6 Depiction of Democritus

Aristotle (384–322 BCE)

Aristotle was perhaps the most multi-disciplined of all of the Ancients (Fig. 2.7). His contributions span philosophy, mathematics, and most importantly to the current text—mechanics. He was clearly brilliant, as evidenced by his place as tutor to Alexander the Great, as well as his writings on philosophy. As a result, he is considered to be the father of modern logic. More than any other Greek, his works have remained relevant today.

Aristotelian mechanics remained the predominant theoretical framework until the seventeenth century, when it was supplanted by Galileo, Kepler, and Newton (see Chap. 7). Unfortunately, some of his views on mechanics proved to be incorrect, and these errors later caused serious upheaval between the Roman Catholic Church and the scientific community, resulting in quite a few unfortunate disagreements, such as those involving Giordano Bruno (executed by the Inquisition in 1600, see Chap. 7) and Galileo (convicted by the Inquisition in 1633, see Chap. 7).

For example, we have from Aristotle the following: the Moon is a perfect sphere; the Sun orbits the Earth; and heavy bodies fall faster than light ones. Although these were later proven to be incorrect, the fact remains that Aristotelian mechanics prevailed for two millennia, making Aristotle one of the preeminent practitioners of mechanics.

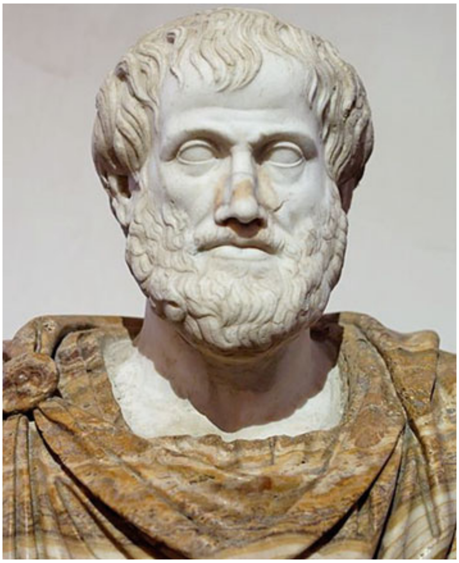

Fig. 2.7 Bust of Aristotle, National Museum of Rome

Euclid of Alexandria (3??–2?? BCE)

Little is known of the life of Euclid of Alexandria, although it is known that he predates Archimedes, who referred to him in his own works. The purists among you may wonder what Euclid is doing in a book on mechanics, since his achievements were in mathematics. To be honest, I have encountered this very problem with a host of Greek scientists—whether or not to include them in this text despite the fact that their contributions were not technically in the field of mechanics. In all other cases I have drawn the line on the conservative side (leaving quite a few deserving scientists out), but in the case of Euclid, I simply could not bring myself to do so. I have only one excuse—this man profoundly affected me personally, and had he not done so, I might not have become a student of mechanics.

I studied Euclidean geometry in high school. Its impact on me was immediate and life-long. And though the mathematics was intriguing, I can honestly say that Euclid's system of logic was what enraptured me so thoroughly. Here is one of the great scientific achievements of antiquity, and I for one believe that much of mechanics derives directly from his logical approach to geometry. Thus, I felt honor-bound to include him in this text.

In his text *Elements,* Euclid deduced the principles of geometry from a small set of fundamental principles called axioms. And amazingly, this approach to geometry (as well as many other fields of science) has endured right down to this day. I felt fortunate to have been taught Euclidean geometry in school. I am

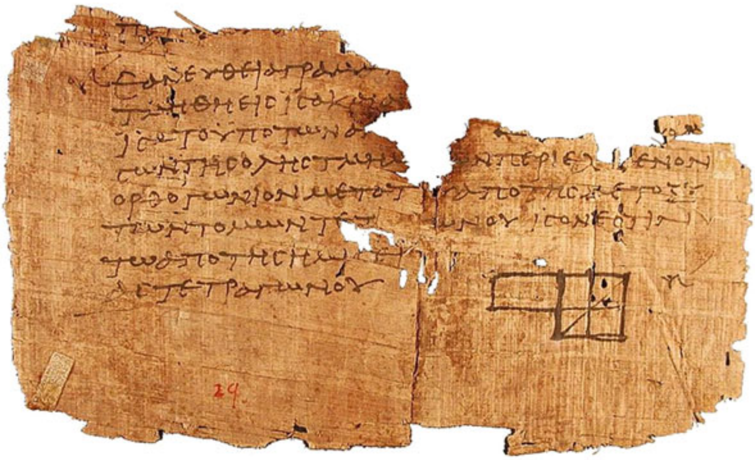

Fig. 2.8 Photograph of one of the oldest surviving fragments of Euclid's *elements*

distraught to learn that the teaching of Euclidean geometry appears to be in rapid decline today. This does not bode well for the future of mechanics, indeed for all of science (Fig. 2.8).

Aristarchus of Samos (310–230 BCE)

Aristarchus was the first person known to have proposed a Sun-centered universe (Fig. 2.9). Once he made the assumption that the solar system is Sun-centered, he was able to predict the order of the planets by observing their motions, a problem in mechanics. He thus placed the planets in correct order within his Sun-centered universe. Unfortunately, his views were not widely accepted until the time of Isaac Newton, as most humans accepted the geocentric theory of Aristotle.

Archimedes (287–212 BCE)

Certainly, there were many Greek scientists before and during the Hellenistic period who studied the motion of bodies, and while Aristotle is known to have expounded the principle of the lever, the historical record must surely point to Archimedes as the most important mechanist from antiquity (Fig. 2.10).

Archimedes gave a detailed account of the principles associated with the lever, and although slightly flawed, they can be said to contain the essential components of modern statics as embodied in Newton's First Law. They may also be viewed as a forerunner of the principle of virtual work.

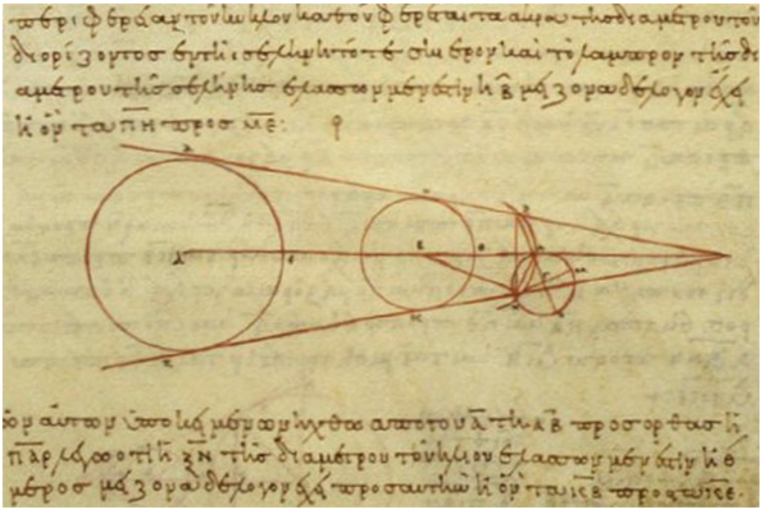

Fig. 2.9 Tenth century AD Greek copy of Aristarchus' second century BCE calculations of the relative sizes of the Sun, Moon, and the Earth, Library of Congress Vatican exhibit

Fig. 2.10 Modern Portrait of Archimedes by Domenico Fetti, Gëmaldegalerie Alte Meister, Dresden

Archimedes' Principles of the Lever are summarized as follows [16]:

Proposition 1 Equal weights at equal distances are in equilibrium, and equal weights at unequal distances are not in equilibrium but incline toward the weight which is at the greater distance.

Proposition 2 If, when weights at certain distances are in equilibrium, something is added to one of the weights, they are not in equilibrium but incline toward that weight to which the addition was made.

Proposition 3 Similarly, if anything is taken away from one of the weights, they are not in equilibrium but incline toward the weight from which nothing was taken.

Proposition 4 When equal and similar plane figures coincide if applied to one another, their centers of gravity similarly coincide.

The Law of the Lever: Two weights balance distances reciprocally proportional to their magnitudes.

The law of the lever may be stated mathematically as follows:

$$M_1 \times L_1 = M_2 \times L_2$$

where the quantities in the above equation are as shown in the figure below. It can be seen that the above formula is a simple application of summation of moments for a body at rest (Fig. 2.11).

While Archimedes' achievements with the lever alone would certainly ensure his place in the history of mechanics, there was much more to come from this great scientist. He also expounded the principle of buoyancy in great detail, thus recording the first significant results on deformable bodies and their properties [17]. He is said to have accomplished this in response to a request by the King of Syracuse. Apparently, the king suspected the goldsmith who had crafted his golden crown to have used some lesser quality metals within the crown. Thus, he charged Archimedes with the responsibility of proving this to be the case.

Archimedes is said to have been bathing at the public bath when he suddenly realized that he needed only to be able to accurately measure the volume of the crown in order to also be able to determine its density (by dividing by its weight, which could be obtained from the above-elucidated principle of the lever). Since he himself had displaced his volume of water when he had stepped into the bathing pool, he realized in a flash that the same technique could be used to measure the volume of the crown (which did in fact turn out to be partly made of lighter metals). It is recorded that in his haste to expostulate this new-found result, he raced through the street naked shouting, "Eureka (I found it!)!"

Archimedes is also known to have proven the relationship between the circumference of a circle and the area, in the process estimating the value of pi

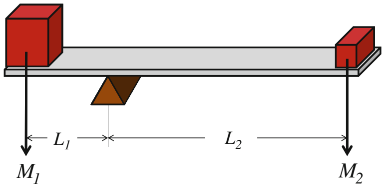

Fig. 2.11 Depiction of terms used in Archimedes' principle of the lever

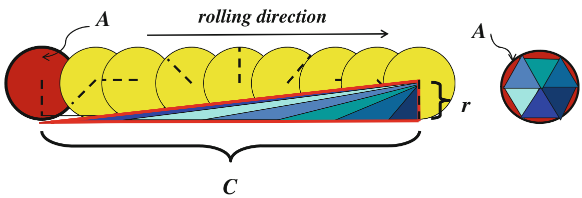

Fig. 2.12 How Archimedes related the circumference of a circle to its area. *Note* that the sum of the bases of the inscribed triangles, each with height r, equals C, the circumference of the corresponding circle

(denoted by the Greek symbol π) quite accurately (see Chap. 7) [18]. To see how Archimedes accomplished this amazing mathematical feat first recall that pi is defined to be the ratio of the circumference, C, divided by the diameter, D, which is also equal to twice the radius, r, so that

$$\pi \equiv \frac{C}{D} = \frac{C}{2r} \Rightarrow C = 2\pi r$$

where the symbol $\equiv$ implies "is defined to be". Archimedes recognized that when he rolled a circle on its edge one complete revolution (C), it plotted out a secession of triangles whose area fit neatly within the area of the circle, as shown above in (Fig. 2.12).

Given that the area of a circle is exactly half of the product of the two perpendicular sides, he was able to calculate the area of the triangle constructed by aligning the triangles:

$$A = Cr/2 \Rightarrow C = 2A/r$$

Archimedes then made his most important step in the proof. By recognizing that the larger the number of triangles that he embedded within the circle, the closer the aligned edges of the triangles approached the circumference of the circle, he concluded that the value of C in the above equation approached the value of the circumference of the circle. He thus equated the two above formulas, giving the following result

$$2\pi r = 2A/r \Rightarrow A = \pi r^2$$

The above is one of the great geometric theorems which come from antiquity. Archimedes went on to utilize the above theorem to prove that both the surface area and the volume of a sphere inscribed within a cylinder of the same radius are exactly two-thirds of the surface area and volume of the cylinder, another important geometric theorem.

Archimedes is also known to have produced a mechanical device for measuring the movements of the known planets, the Sun, and the Moon—an astronomical

Fig. 2.13 Front and rear view photo of the Antikythera clock, Athens Museum

clock if you will. A device called the Antikythera clock was discovered in the Mediterranean in 1901, and it is believed to be a copy (or perhaps the original?) of the device constructed by Archimedes more than 2000 years ago. Today it is considered to be the first *computer* in history (Fig. 2.13).

But there is still more that came from the mind of Archimedes. His home city of Syracuse came under attack by the Romans during the Second Punic War (218–201 BCE) between the Romans and the Carthaginians. Once again the King of Syracuse came to him for help in defending the city against the Romans. Archimedes devised a giant lever that was to be used to swing out over the harbor walls. The lever had a grappling hook attached which was to be used to grasp the Roman triremes and pull the bow out of the water, thus hopefully sinking the ship in the process.

Archimedes apparently wanted to estimate the volume of water that would be necessary for his lever to flood a trireme with in order to sink it. He then reasoned that he could utilize his principle of buoyancy to determine if the trireme could be sunk by this method. He thus produced perhaps the most remarkable theorem from antiquity, calculating the center of gravity of a parabolic cylinder formed by passing a cutting plane through a cylinder at an angle. He determined the volume of the shape produced by first inscribing a triangle within the shape, as shown below. He then used the known area of this triangle, together with the areas of adjacent but smaller triangles to calculate the volume of the irregular shaped object. In so doing, by assuming that there were an infinite number of triangles contained within the object, he used the method of exhaustion (attributed to Eudoxos (410–355 BCE)) in such a way as to introduce the concept of infinity,

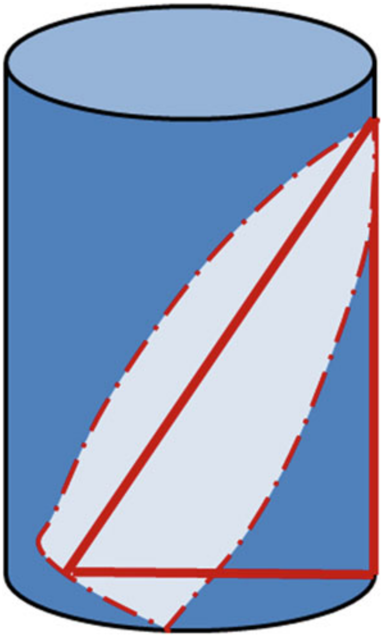

Fig. 2.14 Archimedes' Parabolic Cylinder. *Note* the right triangle inscribed within the volume shown

thereby pointing the way toward the theory of modern calculus, which is a necessary component in any cogent theory of mechanics (Fig. 2.14).

Interestingly, the last of the above developments attributed to Archimedes, although referred to in other literary sources, was not fully verified until a palimpsest was sold at auction at Christie's in 1998 [19]. The palimpsest was discovered during the early twentieth century to have been written over by monks during the Middle Ages with other text. The newly invented technique of x-raying was used to expose the underlying theorem by Archimedes, as shown below. This palimpsest is now under the protection of the Walters Art Museum in Baltimore, Maryland. The proof, found in this palimpsest, has amplified Archimedes' importance to the history of both mathematics and mechanics (Fig. 2.15).

In case it is not obvious, I am a big fan of Archimedes. Although the above discoveries by Archimedes are by no means his only scientific contributions, they are more than sufficient to rank him as the greatest of the ancient mechanists.

There is a story that Archimedes was so proud of his theorem proving that both the surface area and the volume of a sphere inscribed within a cylinder of the same radius are exactly two-thirds of the surface area and volume of the cylinder that he requested that a cylinder and a sphere be placed on his tomb after his death. He was subsequently put to death by a Roman soldier who entered his laboratory during the Siege of Syracuse in 212 BCE. His tomb was apparently constructed according to his wish shortly thereafter.

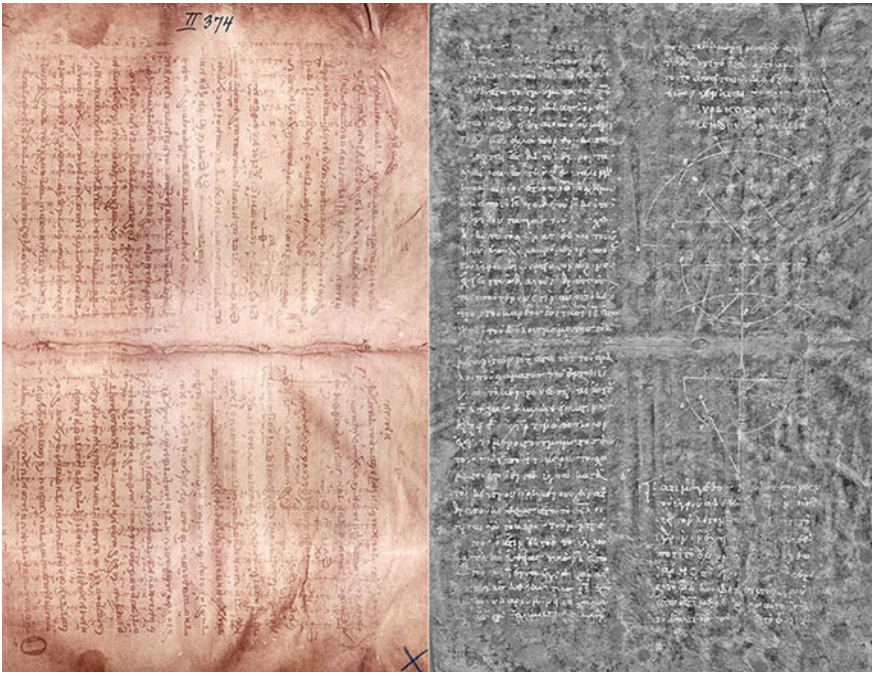

Fig. 2.15 The Archimedes Palimpsest, showing the original text of Archimedes on the *right*, and the overwritten text on the *left*

After his death Archimedes' astronomical clock was spirited away by the Romans and placed in the Roman Forum, where it remained for more than two centuries, thus ensuring that Archimedes' fame would not diminish with time.

Around 70 BCE, the well-known Roman lawyer Cicero (106–43 BCE) was appointed Quaestor on the island of Sicily by the Roman government. During one of his holidays he decided to go in search of the tomb of the famed Archimedes. Cicero described his quest as follows:

> When I was a Quaestor, I tracked down his grave; the Syracusans not only had no idea where it was; they denied it even existed. I found it surrounded and covered by brambles and thickets. I remembered that some lines of doggerel I had heard were inscribed on his tomb to the effect that a sphere and a cylinder had been placed on its top. So I took a good look around (for there are a lot of graves at the Agrigentine Gate cemetery) and noticed a small column rising a little way above some bushes, on which stood a sphere and a cylinder. I immediately told the Syracusans (some of their leading men were with me) that I thought I had found what I was looking for. Slaves were sent in with scythes to clear the ground and once a path had been opened up we approached the pedestal. About half the lines of the epigram were still legible although the rest had worn away. So, you see, one of the most celebrated cities of Greece, once upon a time a great seat of learning too, would have been ignorant of the grave of one of the most intellectually gifted citizens—had it not been for a man from Arpinum who pointed it out to them [20] (Fig. 2.16).

Fig. 2.16 Painting depicting Cicero discovering Archimedes' tomb by Benjamin West (1797)

Today there are several purported sites for Archimedes' tomb, but unfortunately none of them can be authenticated because the identifying sphere and cylinder, as well as the inscription, have long since vanished. This is a great loss in my view. We all need heroes to worship, and what better place to worship them than at their tomb? Try it next time you visit Florence. You will find Galileo's tomb in the Santa Croce Cathedral, with Michelangelo's tomb nearby. You can also see Isaac Newton's tomb in Westminster Abbey, with James Clerk Maxwell nearby.

Eratosthenes of Cyrene (276–195 BCE)

Eratosthenes was apparently the first person to calculate the circumference of the Earth. He also invented a system for determining latitude and longitude, as well as espousing many other important achievements in mechanics (Fig. 2.17).

Eratosthenes, who lived in Alexandria, met a visitor to Alexandria who lived in Swenet (modern day Aswan), at the first cataract of the Nile. Eratosthenes' visitor noted that on the summer solstice the Sun failed to cast a shadow in a water well in Swenet (because it lies on the Tropic of Cancer). Eratosthenes therefore determined the angle, α, that the Sun's shadow cast within a well in Alexandria on the summer solstice, realizing that he could determine the radius of the Earth, r, using this measurement and the distance, d, between Alexandria and Swenet. The distance between these two cities was well known at the time, but just to be safe

Fig. 2.17 Depiction of Eratosthenes

Eratosthenes convinced a friend to journey to Swenet for the purpose of verifying this estimate. The friend returned with the distance measured in stadia (plural of stadion), and from this Eratosthenes was able to calculate the radius of the Earth as follows (using modern notation, where csc is the cosecant):

$$r = \frac{d}{2}\csc\left(\frac{\alpha}{2}\right)$$

From the above it was a simple matter to calculate the circumference of the Earth using Archimedes' formula relating the circumference of a circle to the radius (see the previous section). Although we cannot be certain today of what he meant by the unit of distance called a stadion (the height of a stadium), it is believed by some that his estimated value was within two percent of the actual circumference of the Earth (Fig. 2.18).

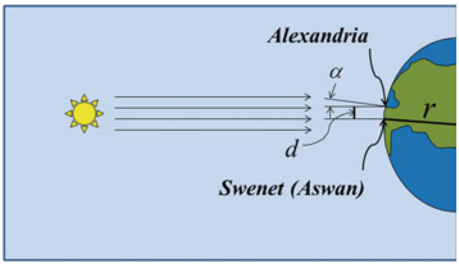

Fig. 2.18 How Eratosthenes calculated the Earth's circumference. *Note* that the sun is so far away from Earth that its rays may be assumed to be approximately parallel

Eratosthenes is also believed to have calculated the distance from the Earth to the Sun, as well as the angle of tilt of the Earth's axis. Furthermore, he is believed to have created the first map of the Earth that used latitude and longitude, and he is credited with the invention of the leap day. All of these achievements are related to mechanics, thereby securing his place as one of the greatest mechanists of antiquity.

Hipparchus of Nicaea (190–120 BCE)

Hipparchus was one of the great mechanists from antiquity. Prior to Ptolemy (see below) he is considered to be the greatest of astronomers among the ancients. His careful measurements of stellar and planetary motions led to his invention of the essential elements of modern trigonometry. Although much of his work survives only indirectly through the published works of Ptolemy (see below), it is known that he was somehow able to predict solar eclipses.

Hipparchus is remembered most importantly for the discovery of the precession of the equinoxes. He apparently wrote two books on this subject, both of which have been lost but are mentioned in Ptolemy's *Almagest*. Ptolemy recounts that Hipparchus measured the longitude of several stars, including Spica and Regulus. He then compared these measurements to those made much earlier by Timocharis and Aristillus. Using these measurements he determined that Spica had moved by two degrees relative to the autumnal equinox. Armed with this result Hipparchus went still further, measuring the length of both the solar and the sidereal years (see Chap. 10). From these comparisons he was able to discern that the equinoxes were precessing through the zodiac at a rate of about one degree per century, thus proving the precession of the equinoxes (see Chap. 10). This is one of the great mechanics achievements from antiquity.

Claudius Ptolemy (c. 90–168 AD)

Ptolemy, perhaps the last of the great Greek mechanists, was a Greek citizen living in Egypt (Fig. 2.19). He wrote the *Almagest* [21], the most widely accepted description of the solar system up until the publication of Nicolaus Copernicus' book in the sixteenth century. Although Ptolemy's epicycle-based methods for calculating the motions of the planets in an Earth centered solar system are essentially mathematically correct, they do not satisfy Ockham's razor (to be discussed in Chap. 4). The *Almagest* was therefore eventually supplanted by Nicolaus Copernicus' book *De Revolutionobus Orbium Coelestium* [22] (see Chap. 7).

There are literally dozens of ancient Greek scientists and philosophers known to us by name today. I have mentioned only a few here, those who in my view made the most significant contributions to mechanics (Fig. 2.20).

Fig. 2.19 Image of Claudius Ptolemy

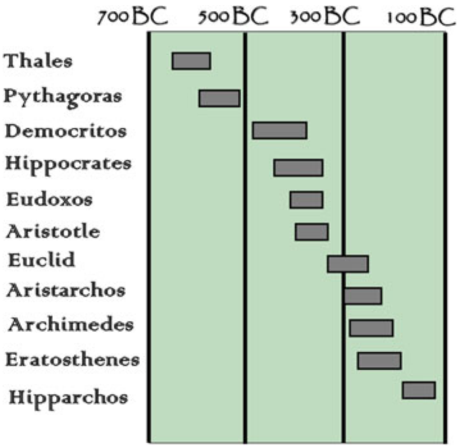

Fig. 2.20 Chronology of greek scientists

Other Greek Mechanists

There were indeed too many Greek scientists who contributed to the field of mechanics to consider in detail in this text. Nonetheless, I have attempted to provide a list below that will give the interested reader a place to start when studying this period of history (Fig. 2.21).

Name	Life Span	Contribution to Mechanics
Anaximander	c. 610–c. 546 BCE	Drew one of the first maps
Cleostratus	c. 520–432 BCE	Studied the zodiac, improved the calendar
Meton of Athens	Fifth century BCE	Introduced Metonic lunar cycle
Hippocrates	c. 460– c. 370 BCE	Father of western medicine
Oenipides	c. 450 BCE	Measured angle between the celestial equator and the zodiac
Harpalus	c. 450 BCE	Invented nine year cycle
Hicetus	c. 400–335 BCE	Believed apparent movement of stars was caused by the Earth's rotation
Heraclidus Ponticus	c. 390–310 BCE	Said the Earth rotates once every 24 hours
Bion of Abdera	?	First to say that parts of the Earth experience 6 months of day, and 6 months of night
Callippus	c. 370–300 BCE	Studied precession of the Earth
Autolycus of Pitane	c. 360– c. 290 BCE	Astronomy, writings on spheres
Timocharis	c. 320–260 BCE	Astronomical observations among the oldest recorded
Diodorus of Alexandria	?	Wrote the first discourse on the principles of the sundial
Apollonius of Perga	c. 262–190 BCE	Astronomy, writings on conics
Hypsicles	c. 190–120 BCE	Wrote on zodiac movements
Carpus of Antioch	Second century BCE?	May have defined the term "angle".
Posidonius	c. 135–51 BCE	Polymath who measured the size of the Sun
Geminus	First century BCE	Wrote a book on astronomy
Menelaus of Alexandria	c. 70–140 AD	First to relate geodesics to straight lines
Hypatia	c. 350–415 AD	First well–documented woman in mathematics

Fig. 2.21 Contributions of selected Greeks to mechanics

Archeology of Greece

Around 800 BCE Homer wrote a tale called *The Iliad*, depicting an account of a 10-year war between the Greeks and the Trojans sometime during the twelth century BCE. The story goes that the war reached its climactic end when the Greeks built the Trojan horse, thereby gaining entrance to Troy by stealth. This fabulous tale, along with its sequel *The Odyssey*, became a significant underpinning of the enormously influential culture of Greece that arose shortly thereafter (Fig. 2.22).

This epic tale became so important in the ancient world that the Romans created their own legend based on *The Iliad*. Around 20 BCE Virgil wrote the epic tale *The Aeneid*, in which he amplified the tale of one Aeneus, a character described in *The Iliad.* In the story, Aeneus wanders for many years, finally settling in Italy, and

Fig. 2.22 Depiction of the story of the Trojan horse in the art of ancient Gandhara, British Museum

becomes the ancestor of the Roman Republic. The Romans used this epic tale to give their own mythical history legitimacy.

Time passed, and with it, the influence of both the Greeks and Romans, as well as their tales of the Trojan Wars waned. By the time of the Renaissance Homer's classic tales had become revered as the greatest fictional tales from antiquity. But were they indeed fiction, or was there a possibility that they were in fact based on reality? One person, a wealthy haberdasher by trade, decided in the middle of the nineteenth century that these tales were in fact founded in truth. His name was Heinrich Schliemann (1822–1890), and although he is not the first person to address this mystery his persistence has made him (arguably) one of the founders of modern archeology [23].

Schliemann decided to go to Western Turkey, where the Trojan Wars were described to have taken place in *The Iliad*. Using the description of the site of the wars described in the Iliad, Schliemann picked a spot at Hisarlik (meaning "place of fortresses"), approximately 6.5 km equidistant from both the Aegean Sea and the Dardanelles. This spot had been previously picked out as the site of Troy in the fifteenth century by Pedro Tafur (c. 1410–1484). Still later, in the nineteenth century Frank Calvert (1828–1908) began studying the site (Fig. 2.23).

It was at this point that Schliemann arrived and took over excavation of the site. Possessed of significant financial resources, Schliemann was able to make rapid progress with the excavations (some say too rapid), and in the process going a long way toward restoring the myth of Troy to the status of history (Fig. 2.24).

Schliemann eventually uncovered multiple layers of the ancient city, as shown below. However, the legitimacy of Hisarlik as the actual site of the Trojan Wars remains in considerable doubt today (Fig. 2.25).

Not content with this feat, Schliemann then took on the site of Mycenae in the Peloponnesian peninsula of Greece, supposedly founded by Perseus, the slayer of the mythical Medusa. Mycenae was also the supposed home of Agamemnon, the Greek King from the Trojan Wars. The site had already been partially excavated in 1841 by Greek archeologist Kyriakos Pittakis (1798–1863) (Fig. 2.26). Although Pittakis excavated the famous Lion's Gate, his excavation was incomplete (Fig. 2.27).

Fig. 2.23 Photograph of Frank Calvert

Fig. 2.24 Photograph of Heinrich Schliemann

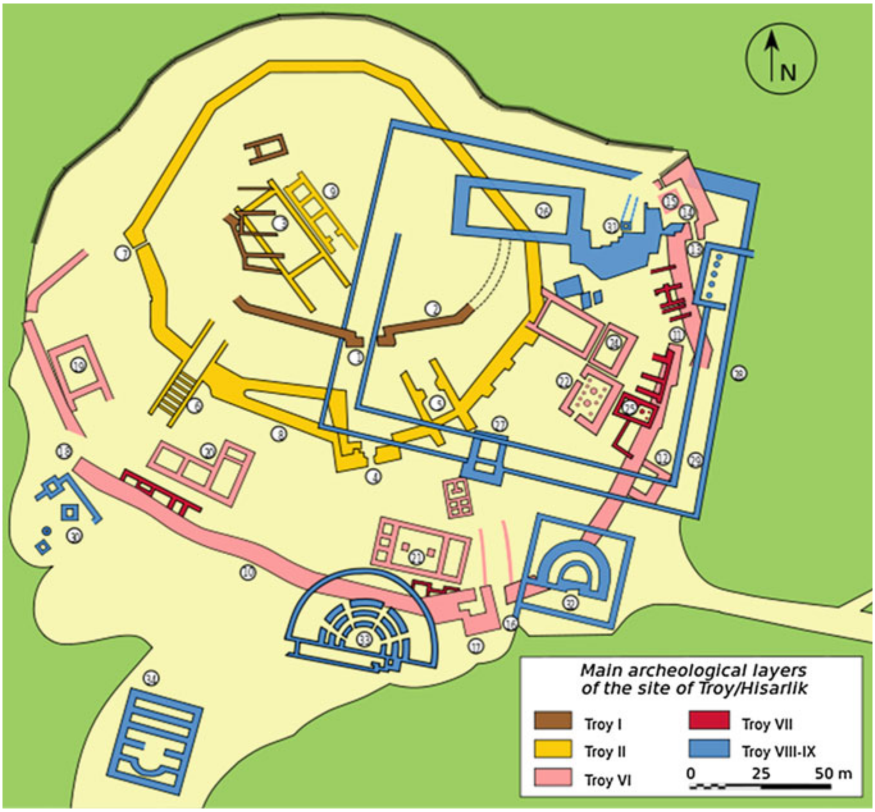

Fig. 2.25 Plan of ancient Troy

Fig. 2.26 Photograph of Kyriakos Pittakis

Fig. 2.27 Photograph taken circa 1884 of the Lion's Gate at ancient Mycenae

Fig. 2.28 Photograph of the Mask of Agamemnon, Athens Museum

Fig. 2.29 The Tomb of Clytemnestra

Schliemann arrived at Mycenae in 1876, and he undertook a much more detailed excavation of the site. In doing so, he discovered thousands of relics from the past, including the famous "Mask of Agamemnon" (Fig. 2.28). He also discovered several tombs, including the tomb of Clytemnestra, the wayward wife of Agamemnon (Fig. 2.29).

All of these discoveries showed signs of advanced mechanics being used by humans as far back as the thirteenth century BCE. Construction of large stone structures apparently became ubiquitous throughout the ancient world. In addition, the working of precious metals was clearly accomplished with advanced tools designed for more precise uses.

The Greeks established a style of construction that has endured right down to this very day. The columnar design used in the Parthenon was adopted by the Romans, and they propagated this style with little variation across the Roman Empire, which had grown by the first century AD to mammoth proportions.

More importantly, the Greeks laid the groundwork for all of modern mechanics via their scientific revelations, as described above. Thus, there was enough to build on when Western Europe awakened from the Middle Ages, as we will see in Chap. 7.

The Romans eventually appropriated Greece as a part of their empire, and when they did, they came in contact with Greek science and technology. As we will see in the next chapter, they learned a great deal from the Greeks.

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